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IS 14698 (1999): Carbon and Low Alloy Steel Billets, Blooms, Slabs and Bars for Manufacture of Shell Bodies and Proof Shots Used in Defence Services [MTD 16: Alloy Steels and Forgings]

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रक्षा सेवाओं में प्रयुक्त प्रूफ शॉट और शैल बॉडी के निर्माण के लिए कार्बन तथा अल्पमिश्र धातु इस्पात के बिलेट, ब्लूम, सिल्लियां एवं छड़ें — विशिष्टि

Indian Standard

CARBON AND LOW ALLOY STEEL BILLETS, BLOOMS, SLABS AND BARS FOR MANUFACTURE OF SHELL BODIES AND PROOF SHOTS USED IN DEFENCE SERVICES — SPECIFICATION

ICS 77.140.60

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 1999 **Price Group 6**

Alloy Steels and Forgings Sectional Committee, MTD 16

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Alloy Steels and Forgings Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard is one of the important in the series for the development of national standard in response to a request received from Ministry of Defence. This standard will be very useful for the procurement of quality steel from different sources in the country for defence purposes. This standard is based on the present manufacturing and trade practices being followed in the country in this field.

In the preparation of this standard assistance has been derived from Joint Service Specification, JSS 9501-1 : 1982 'Steel for shell bodies and proof shot' issued by Ministry of Defence.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or caluclated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specifed value in this standard.

Indian Standard

CARBON AND LOW ALLOY STEEL BILLETS, BLOOMS, SLABS AND BARS FOR MANUFACTURE OF SHELL BODIES AND PROOF SHOTS USED IN DEFENCE SERVICES — SPECIFICATION

1 SCOPE

This standard covers the requirements for supply and inspection of carbon and low alloy steel bars, billets, blooms and slabs for the manufacture of shell bodies and proof shots used in defence services.

2 REFERENCES

The Indian Standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated.

3 SUPPLY OF MATERIAL

3.1 General requirements to the supply of material shall be as laid down in IS 1387 unless specifically mentioned in the order.

3.2 The steel covered in this standard shall be ordered and supplied on the basis of following:

a) Chemical composition;
b) Mechanical properties;
c) Macro-etch test; and
d) Any other test as agreed to between the purchaser and the supplier.

3.2.1 For leaded steel bars and for slabs some other special tests as given in **10.1** are also required to be conducted. These additional tests if require, shall be included in the purchase order as per mutual agreement between the purchaser and the supplier.

4 MANUFACTURE

4.1 The steel shall be supplied in fully killed condition except for the free cutting grades which may be supplied in semi-killed condition as per agreement between the purchaser and the supplier. The steel shall however be free from harmful defects such as seams, flaws, piping, cracks and the surface defects.

4.1.1 Unless otherwise agreed to, the processes employed for steel making shall be left to the discretion of the manufacturer. However if desired, the purchaser may be informed of steel making process. The continuous casting process shall, however, not be employed for manufacture without prior permission of the purchaser.

4.1.2 Vacuum Degassing or any other refining process may be adopted with prior approval of the purchaser or by mutual agreement or at the option of the manufacturer to achieve the specified properties.

4.1.3 Sufficient top and bottom discards shall be made to ensure internal soundness and freedom from harmful defects such as piping, segregation, etc.

4.1.4 Adequate precautions shall be taken during processing to avoid development of hair line cracks.

4.1.5 All the harmful surface defects on blooms, billets, slabs and bars above 50 mm shall be removed to the satisfaction of the purchaser. For bars below 50 mm grinding may be performed before drawing them to the required size.

4.1.6 For lead bearing steels adequate bottom discard shall be made to ensure freedom from lead segregation.

4.1.7 The slabs shall conform to the composition as given at serial number 29 of Table 2 and the steel shall be supplied in fully killed condition.

4.1.8 Composition of steel and its method of manufacture shall be such that when subjected to carburizing test at 900°C for six hours or any other similar test it shall show a grain size of Grades 2 to 4 (both inclusive) as per IS 4748.

4.2 Identification

4.2.1 At all the stages of processing the steel shall be suitably marked indicating:

a) the cast/heat number;
b) number of this standard;
c) manufacturer's identification mark; and

d) any additional markings, as desired by the purchaser and found necessary as per mutual agreement with the supplier.

4.2.2 In exceptional cases, where the identity of a batch has been lost accidentally, random sampling from the batch may be resorted to with approval of the purchaser.

4.3 General

4.3.1 *Inspection and Testing*

4.3.2 The purchaser shall be given full opportunity to inspect/test the steel at any time/stage of manufacture.

4.3.3 The steel maker shall inform the purchaser with adequate notice his schedule of production/ manufacture and shall also provide adequate facilities for inspection and testing. The inspection and testing shall be conducted as laid down in Annex B.

5 CONDITION OF SUPPLY

5.1 General

5.1.1 Material shall normally be supplied in the as-rolled or normalized condition including for forgings unless otherwise specified.

5.1.2 Bars for machining shall be supplied in the as-rolled condition. However, if the material fails to comply with the requirements of mechanical properties in as-rolled condition, it may be normalized at 850 to 900°C and re-offered for inspection.

5.1.3 Rounds for machining above 225 mm dia, shall be supplied in the normalized condition.

5.1.4 All steel bars for machining may be cold sized subject to the reduction in diameter not exceeding 0.4 mm. The bars shall be finally reeled.

5.2 Material to be Supplied in the Cold Drawn Condition

5.2.1 For steels required to be supplied in the cold drawn condition, the diameter of the black bar shall be such that it does not exceed the diameter of the cold drawn bar by more than 1.6 mm.

5.2.2 All the cold drawn material shall be subjected to proof stress test in compression in addition to the tensile test as given in Table 3.

5.2.3 Cold drawn steels, having proof stress (*PS*) in compression of more than 450 MPa shall be subjected to a uniform stress relieving at a temperature between 400°C and 450°C.

5.2.4 If any steel does not meet the requirements of proof stress in compression, it may be subjected to similar stress relieving as indicated in **5.2.3**.

5.3 Material to be Used in Hardened and Tempered Condition

Bars for machining are to be supplied in as-rolled, normalized, and low temperature annealed or hardened and tempered condition as agreed between the purchaser and the supplier.

6 DIMENSIONAL TOLERANCES

6.1 Bars may be supplied in the lengths varying between 2.5 to 5.5 m. However in a lot 10 percent short lengths up to 1.5 m may be permitted.

6.2 Straightness

The bars shall be straight within 3 mm for every metre length.

6.3 Twist

All bars shall be free from any twist.

6.4 The tolerance on cross-section for billets, blooms and slabs shall be as given below:

Cross-Sectional Dimension, mm	*Permissible Tolerances,* mm
Up to 100	± 1.5
100 to 150	+ 4.5 – 2.0
Above 150	+ 6.0 – 3.0

6.5 The dimensional tolerances for black bars shall be in accordance with IS 3739. The tolerances for peeling/drawn bars shall however be as given in Table 1.

7 CHEMICAL COMPOSITION

7.1 Ladle Analysis

Ladle analysis of the material when carried out either by the methods specified in the relevant part of IS 228 or any other established instrumental/chemical method, shall be as given in Table 2. In case of dispute, the procedure given in the relevant part of IS 228 shall be the referee method. However, where the method is not given in IS 228 or its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

7.2 Product Analysis

7.2.1 The product analysis shall be carried out on the finished product from the standard position. Permissible variation in case of product analysis from the limits specified in Table 2 shall be as given in Table 3.

7.2.2 For lead bearing steels, separate samples shall be drawn as per **11** and analyzed for lead content which should be within 0.10 to 0.30 percent.

Table 1 Dimensional Tolerances for Drawn Bars

(*Clause* 6.5)

Size, mm (Diameter, A/F, Thickness or Width)		**Variation, *Max*, mm**			
		Round Sections			Squares, Hexagon and Flats Cold Drawn
Over	Up to and Including	Ground	Turned	Cold Drawn	
(1)	(2)	(3)	(4)	(5)	(6)
—	3	– 0.025	—	– 0.06	– 0.06
3	6	– 0.030	—	– 0.07	– 0.07
6	10	– 0.036	—	– 0.09	– 0.09
10	18	– 0.043	– 0.11	– 0.11	– 0.11
18	30	– 0.052	– 0.13	– 0.13	– 0.13
30	50	– 0.062	– 0.16	– 0.16	– 0.16
50	80	– 0.074	– 0.19	– 0.19	– 0.19
80	120	– 0.087	– 0.22	– 0.22	– 0.22
120	180	– 0.100	– 0.25	– 0.25	– 0.25

Table 2 Chemical Composition

(*Clauses* 4.1.7, 7.1, 7.2.1 *and* 7.3)

Sl No.	**Grade Designation**	**Constituent, Percent**									
		C	Si	Mn	S *Max*	P *Max*	Ni	Cr	Mo	Cu	Sn/Al
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	45C8	0.40 to 0.50	0.10 to 0.35	0.70 to 1.00	0.040	0.040	—	—	—	—	—
2	50C9	0.45 to 0.55	0.10 to 0.35	0.70 to 1.10	0.040	0.040	—	—	—	—	—
3	40C12	0.35 to 0.45	0.10 to 0.35	1.00 to 1.50	0.040	0.040	—	—	—	—	—
4	60C6	0.55 to 0.65	0.10 to 0.35	0.50 to 0.80	0.040	0.040	—	—	—	—	—
5	48Mn6Mo1	0.43 to 0.53	0.10 to 0.35	1.20 to 1.70	0.040	0.040	—	—	0.20 *Max*	—	—
6	38Mn7Ni2Mo2	0.35 to 0.42	0.10 to 0.35	1.60 to 1.85	0.040	0.040	0.50 to 0.75	—	0.15 to 0.30	—	—
7	35Mn6Mo2	0.30 to 0.40	0.10 to 0.35	1.20 to 1.60	0.040	0.040	—	—	0.15 to 0.30	—	—
8	40Mn6Mo2	0.35 to 0.45	0.10 to 0.35	1.20 to 1.60	0.040	0.040	—	—	0.15 to 0.30	—	—
9	40C12S16	0.35 to 0.45	0.25 *Max*	0.90 to 1.40	0.12 to 0.20	0.060	—	—	—	—	—
10	48C8S20	0.46 to 0.51	0.20 to 0.35	0.70 to 0.90	0.18 to 0.22	0.060 to 0.80	—	—	—	—	—
11	40Mn6Mo2S16	0.35 to 0.45	0.25 *Max*	1.20 to 1.65	0.12 to 0.22	0.060	—	—	0.15 to 0.30	—	—
12	27C12	0.22 to 0.32	0.10 to 0.35	0.90 to 1.40	0.040	0.040	—	—	—	—	—
13	30Mn5Mo2	0.22 to 0.32	0.10 to 0.35	0.90 to 1.40	0.040	0.040	—	—	0.15 to 0.30	—	—
14	30C12S16	0.25 to 0.35	0.25 *Max*	0.90 to 1.40	0.120 to 0.20	0.060	—	—	—	—	—

Table 2 (*Concluded*)

Sl No.	Grade Designation	Constituent, Percent									
		C	Si	Mn	S	P	Ni	Cr	Mo	Cu	Sn/Al
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
15	30Mn5Mo2S16	0.25 to 0.35	0.25 *Max*	0.90 to 1.40	0.120 to 0.20	0.060	—	—	0.15 to 0.30	—	—
16	44C15S24	0.40 to 0.48	0.15 to 0.30	1.35 to 1.65	0.240 to 0.33	0.040	—	—	—	—	—
17	22Mn5Ni3Mo2	0.19 to 0.24	0.10 to 0.35	1.00 to 1.30	0.040	0.040	0.60 to 1.00	—	0.15 to 0.25	—	—
18	28Cr6Ni3Mo3	0.26 to 0.30	0.10 to 0.35	0.40 to 0.80	0.040	0.040	0.60 to 0.90	1.30 to 1.70	0.25 to 0.40	—	—
19	45Mn2Mo1	0.30 to 0.60	0.10 to 0.35	1.00 *Max*	0.040	0.040	—	—	0.05 to 0.20	—	—
20	35Mn6Mo3	0.30 to 0.40	0.10 to 0.35	1.30 to 1.80	0.040	0.040	—	—	0.20 to 0.35	—	—
21	45Cr5	0.40 to 0.50	0.10 to 0.35	0.50 to 0.80	0.040	0.040	—	1.10 to 1.40	—	—	—
22	45Cr11	0.40 to 0.50	0.10 to 0.35	0.50 to 0.80	0.040	0.040	—	2.40 to 2.90	—	—	—
23	36Si6Cr5Mn4	0.32 to 0.39	1.30 to 1.60	0.80 to 1.10	0.040	0.040	—	1.10 to 2.90	—	—	—
24	50C6	0.45 to 0.55	0.10 to 0.35	0.50 to 0.80	0.040	0.040	—	0.30	—	—	—
25	115C5	1.10 to 1.20	0.10 to 0.35	0.40 to 0.60	0.040	0.040	—	0.20	—	—	Al 0.025
26	70C4	0.68 to 0.73	0.10 to 0.35	0.30 to 0.50	0.040	0.040	—	0.30	0.08	—	Al 0.030
27	36Ni6Cr6Mo2	0.32 to 0.39	0.10 to 0.35	0.50 to 0.80	0.040	0.040	1.20 to 1.60	0.20 to 1.60	0.15 to 0.25	—	—
28	26Cr4Mo2	0.22 to 0.29	0.10 to 0.35	0.50 to 0.80	0.040	0.040	—	0.90 to 1.20	0.15 to 0.30	—	—
29	26Mo1	0.23 to 0.30	0.10 to 0.35	0.60 to 0.90	0.040	0.040	—	0.20 *Max*	0.10 *Max*	—	0.04 *Max*

NOTE — Steel Grade 26Mo1 is for the manufacture of slabs and sheets required to be deep drawn. If (Ni+Cr+Cu+Mo) content is less than 0.45 percent, then C will be 0.25 to 0.30 percent and Mn will be 0.70 to 0.90 percent respectively. Otherwise C will be 0.23 to 0.28 percent and Mn will be 0.60 to 0.80 percent respectively.

7.3 Residual Element

The elements, which have not been specified in Table 2, shall not be added to the steel and as residual elements their percentage shall not exceed the following limits:

Element	*Percent, Max*
Nickel	0.50
Chromium	0.30
Copper	0.30
Molybdenum	0.06
Vanadium	0.05
Tin	0.05

NOTE — Tin shall not exceed 0.04 percent and (Sn × 10 + Cu) shall not exceed 0.5 percent. The total residual elements shall not exceed 0.80 percent except for grade 44C15S24 where the limit shall be 0.65 percent.

8 MECHANICAL PROPERTIES

8.1 Mechanical tests shall be carried out on samples drawn as per **11.2** after giving proper heat treatment, wherever applicable, as per Table 4. The test results shall conform to the requirements given in Table 4.

8.2 Tensile strength including 0.2 percent proof stress shall be determined in accordance with IS 1608, on a test piece using proportional gauge

Table 3 Permissible Variation for Product Analysis

(*Clauses* 5.2.2, 7.2.1 *and* 11.2.1)

Constituent	Percent	Permissible Variation, Percent	
		For Sections Up to and Including 250 mm	For Sections Over 250 mm and Up to and Including 500 mm
(1)	(2)	(3)	(4)
Carbon	Up to and including 0.25	± 0.02	± 0.04
	Over 0.25 and up to and including 0.50	± 0.03	± 0.05
	Over 0.50	± 0.04	± 0.06
Silicon	Up to and including 0.40	± 0.03	± 0.04
	Over 0.40 and up to and including 2.00	± 0.05	± 0.07
Manganese	Up to and including 1.20	± 0.04	± 0.06
	Over 1.20 and up to and including 2.00	± 0.05	± 0.07
Phosphorus	—	+ 0.005	+ 0.010
Sulphur	—	+ 0.005	+ 0.010
Nickel	Up to and including 1.0	± 0.03	± 0.03
	Over 1.0 and up to and including 1.6	± 0.05	± 0.05
Chromium	Up to and including 0.80	± 0.03	± 0.04
	Over 0.80 and up to and including 2.2	± 0.05	± 0.06
	Over 2.2 and up to and including 2.9	± 0.11	± 0.13
Molybdenum	Up to and including 0.40	± 0.03	± 0.04

length $L_0 = 5.65\sqrt{S_0}$ where S_0 is the original cross-sectional area of the test piece. Test pieces with a non-proportional gauge length may also be used and in such case the elongation values obtained shall be converted in accordance with IS 3803 (Part 1).

8.3 Cold drawn products shall be tested for 0.2 percent proof stress in compression in addition to tensile tests.

8.3.1 Compression test piece of size 20 mm long × 20 mm dia with perfectly square end faces shall be drawn as given in **11.3**.

8.3.1.1 A conditioning load of 80 MPa shall be applied to the test piece first and the dimensions shall then be measured. The proof load calculated according to the measured dimensions is then to be applied for 10 s and the test piece shall be re-measured. The test piece shall not exhibit permanent set more than 0.2 percent (0.04 mm for this test piece).

8.4 Wherever specified, the impact test shall be carried out in accordance with IS 1499, IS 1757 and IS 1598. The requirements shall be as specified in Table 4.

8.5 Wherever specified, the hardness of the steel shall be as given in Table 4 when tested in accordance with IS 1500.

9 MACRO-ETCH TEST

9.1 Macro-etch test shall be carried out in accordance with IS 11371.

9.2 Acceptable standards for macro-etch test shall be C-1 S-2 and R-2 as per plate I of IS 13015.

9.3 The sample for macro-etching should exhibit freedom from harmful defects such as cracks, flakes, gassiness, splash and tears.

9.4 For each of the original test piece that fails to comply to the macro-etch test, two more samples shall be selected for retests, one of which shall be from the bar/billet/slab/bloom from which the original test sample was taken, unless otherwise that item has been withdrawn by the manufacturer in which case a fresh bar/billet/slab/blooms shall be selected.

10 SPECIAL TESTS

10.1 Test for Lead Segregation

10.1.1 This test shall be carried out for lead bearing steels. A section of the billet or bar adjacent to the bottom discard of every ingot in the cast shall be taken for this test and heated to a temperature of 600°C, *Min*. Alternatively a flame be ap-plied to the end of the billet or bar until the surface oxidizes to a blue-grey colour.

Table 4 Mechanical Properties with Heat Treatment

(*Clauses* 8.1, 8.4, 8.5 *and* 11.2.1)

Sl No.	Grade Designation	Condition of Supply	Size of Test Samples	Heat Treatment of Test Sample	Mechanical Properties						
					0.2 Percent Proof Stress, MPa	Tensile Strength, MPa		Elongation at $5.65\sqrt{S_o}$ Percent	Reduction in Area, Percent	Impact Strength	
										Izod Joules	Charpy Joules
					Min	*Min*	*Max*	*Max*	*Min*	*Min*	*Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	45C8	Billets and bars for forging as-rolled	Full section	Normalized 850/900°C	290	—	740	12	—	—	—
2	45C8	Billets and bars for machining as-rolled	do	None	310	—	770	12	—	—	—
3	50C9	do	do	do	320	—	770	12	—	—	—
4	40C12	Billets and bars for forging or machining as-rolled	do	Normalized 850/900°C	370	—	820	12	—	—	—
5	60C6	do	do	None	400	—	900	12	—	—	—
6	48Mn6Mo1	do	do	do	420	—	930	10	—	—	—
7	38Mn7Ni2Mo2	do	do	do	590	—	960	10	—	—	—
8	35Mn6Mo2	do	do	do	470	—	850	10	—	—	—
9	40Mn6Mo2	do	do	do	500	—	850	10	—	—	—
10	40C12S16	Free cutting bars for machining as-rolled or normalized	do	do	370	—	770	10	—	—	—
11	48C8S20	do	do	do	370	—	850	13	—	—	—
12	40Mn6Mo8S16	do	do	do	470	—	930	10	—	—	—
13	27C12	a) Cold drawn bars low temperature annealed	do	do	420	—	770	10	—	—	—
		b) do	do	do	500	—	850	8	—	—	—
14	30Mn5Mo2	Cold drawn bars low temperature annealed	Full section	do	500	—	850	10	—	—	—
15	30C12S16	a) Free cutting cold drawn bars low temperature annealed	—	—	370	—	770	10	—	—	—
		b) do	—	—	470	—	850	8	—	—	—
16	30Mn5Mo2S16	do	—	—	500	—	850	10	—	—	—

Table 4 (*Continued*)

Sl No.	Grade Designation	Condition of Supply	Size of Test Samples	Heat Treatment of Test Sample	Mechanical Properties						
					0.2 Percent Proof Stress, MPa	Tensile Strength, MPa		Elongation at $5.65\sqrt{S_o}$ Percent	Reduction in Area, Percent	Impact Strength	
										Izod Joules	Charpy Joules
					Min	*Min*	*Max*	*Max*	*Min*	*Min*	*Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
17	44C15S24	Free cutting cold drawn bars low temperature annealed	—	—	830 (*See* Note 1)	—	1 080	4	—	—	—
18	22Mn5Ni3Mo2	Billets and bars for forging and machining	20 mm dia	H=840/860°C W.Q. T=650°C *Min*	470	620	—	24	—	54	—
19	28Cr6Ni3Mo3	do	30 mm dia	H=850/870°C O.Q. T=600/650°C	590	850	—	12	—	35	—
20	48Mn6Mo1	do	Ruling Section as ordered	H=820/840°C O.Q. T=550/650°C	590	850	—	8	—	17	—
21	45Mn2Mo1	Billets and bars for forging	Full section normalized	Normalized as per composition	310 *Min* 490 *Max*	590	885	—	—	—	—
		do	Ruling section as ordered for hardened and temperature condition	Hardening = 590°C Tempering as per composition	835	—	—	8	—	—	—
22	35Mn6Mo2	Billets and bars for forging and machining	Ruling section as ordered	H=820/840°C O.Q. T=550/650°C	770	1 000	—	10	—	—	47
23	35Mn6Mo3	do	LRS-63 mm	H=840/860°C W.Q. or O.Q. T=550/600°C	700	900	1 050	—	15	—	55
			LRS-30 mm	do	800	1 000	1 150	13	—	48	—
24	45Cr5	do	LRS-25 mm	H=840/860°C O.Q. T=500/550°C W.Q. or O.Q.	—	980	—	—	35	—	49
25	45Cr11	do	do	H=840/860°C O.Q. T=500/530°C W.Q. or O.Q.	—	980	—	—	35	—	49
26	36Si6Cr5Mn4	do	LRS-25 mm	First hardening 940-960°CO.Q. T=700-720°C Second Hardening 880/890°C, O.Q. T=220/240°C	—	1 568	—	—	35	—	29

Table 4 (*Concluded*)

Sl No.	Grade Designation	Condition of Supply	Size of Test Samples	Heat Treatment of Test Sample	Mechanical Properties						
					0.2 Percent Proof Stress, MPa	Tensile Strength, MPa		Elongation at $5.65\sqrt{S_o}$ Percent	Reduction in Area, Percent	Impact Strength	
										Izod Joules	Charpy Joules
					Min	*Min*	*Max*	*Max*	*Min*	*Min*	*Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
27	50C6	Cold drawn	Full section	None	638	—	—	—	20	—	—
28	115C5	Billets for forging to be supplied as-rolled and normalized	do	do	490	900	—	4	—	—	—
29	70C4	Billets for forging to be supplied as-rolled	do	None	400	790	—	7-16 on GL= 10 ø	—	—	—
30	36Ni6Cr6Mo2	Billets and bars for forging and machining	Up to 250 mm	H=830-860°C O.Q. T=550/675°C 270-325 HB	700	900	1 100	12	45	—	—
31	26Cr4Mo2	do	Up to 16 mm	H=850/870°C O.Q. or W.Q. T=540/680°C	686	883	1 079	12	50	55	—
			16 to 40 mm	do	588	785	932	14	55	63	—
			40 to 100 mm	do	461	687	834	15	60	63	—
			100 to 160 mm	do	412	637	765	16	65	63	—

NOTES

1 In compression 0.02 percent Proof Stress = 740 Mpa, *Min.*

2 Full nomenclature of the abbreviations:

LRS = Limiting ruling section
H = Hardening
T = Tempering
W.Q. = Water quenching
O.Q. = Oil quenching

10.1.2 If small Beads of extruded lead are found on the surface of the heated section, further discards are to be given until the test is satisfactory.

10.1.3 However, beads of size not more than 0.4 mm and well distributed may be accepted. Few larger beads also may be accept-ed if they are not accompanied by clusters of smaller beads.

10.1.4 Lead segregation may also be tested by taking lead prints of the ground end surface, the standard of acceptance in this case shall be agreed between the purchaser and the supplier .

10.2 Test for Cleanliness

If required by the purchaser the cleanliness of steel shall be tested in accordance with IS 4163. Acceptance standards for this test shall be as agreed to between the purchaser and the supplier.

10.3 Magnetic Particle Inspection/Eddy Current Testing

If so desired by the purchaser, magnetic particle inspection/eddy current testing may be carried out in accordance with IS 3703/IS 13190 to ensure that both black and bright bars are free from any cracks.

10.4 Sulphur Print

If so desired by the purchaser, freedom from piping and segrega-tion may also be ensured by examination of sulphur prints in accordance with IS 12037. The requirements shall be mutually agreed to between the purchaser and the supplier.

10.5 Analysis for Heterogeneity

10.5.1 To examine the relation of heterogeneity of the steel and results of mechanical tests, samples drawn as given below may be analyzed for chemical composition.

10.5.2 After requisite discards, drillings shall be taken from a position mid-way between the centre and outside, from the top end of first ingot in case of top pouring or from the ends of the billets or bars corresponding with that position. In case of bottom pouring samples shall be taken from top of one ingot from the first plate. A 25 mm drill shall be used for product size 100 mm and above, and below 100 mm, a 12.5 mm drill shall be used. Alternatively suitable block shall be taken from the identical location as above for instrumental analysis.

11 SAMPLING

11.1 Sampling for Chemical Analysis

11.1.1 Two samples shall be drawn as given in **11.1.2** below from each cast or heat. When the identity of a batch has been lost accidentally, random sampling at the rate of double the number of samples taken at the first instance may be resorted to with the prior approval of the purchaser.

11.1.2 Cut a transverse slice each from the top product of the first ingot or cluster of ingots and bottom product of the last ingot or cluster of ingots of the cast. Then take samples from the two slices separately by milling over the whole surface.

11.2 Sampling for Mechanical Test

11.2.1 Samples of required sizes shall be drawn as stated in **11.2.2**, **11.2.3** and **11.2.4**. Samples shall be heat treated as given in Table 4 and then tested for the properties specified.

11.2.1.1 Details of heat treatment, if any, given to the test piece/sample shall be recorded with the test results.

11.2.2 *Billets or Bars for Forgings*

Two samples, one from immediately below the top discard of the first ingot or first cluster of ingot and the other from immediately above the bottom discard of the last ingot or the last cluster of ingot shall be drawn from each cast.

11.2.2.1 Unless specified in Table 3 or in the order, the test pieces shall be machined longitudinally from the test sample so that their axis lie midway between the centre and the periphery of the sample.

11.2.3 *Bars Supplied in As-Rolled Condition for Machining*

Three test samples shall be drawn on each from the first, middle and the last ingot or the cluster of ingots of the cast.

11.2.3.1 The test samples shall be drawn in such a way that the nearest end of the test piece is minimum 300 mm away from the end of the rolled bar.The test piece shall be machined longitudinally and the axis shall be 12.5 mm below the surface if size of the bar permits.

11.2.3.2 Bars for machining, shall be supplied in normalized, and tempered, or hardened and tempered condition. For every 100 bars or part thereof, pertaining to the same cast and same heat treatment batch, one test sample will be selected from the end of the bar.

11.2.3.3 Drawing of test sample and machining of test piece shall be same as given in **11.2.4.1.**

11.2.4 *Bars for Machining, Supplied in Cold Drawn or Cold Drawn and Low Temperature Treated Condition*

11.2.4.1 For every 100 bars or part thereof, pertaining to same cast (and also same heat treatment batch wherever applicable) one sample shall be selected for tests.

11.2.4.2 The tensile test piece may be taken from the end of the bar. The axis of the test piece may be along the centre of the bar or at a depth of 12.5 mm from the surface.

11.3 Compression Test

All cold drawn bars, without any subsequent full annealing/normalizing treatment, shall be tested for 0.2 percent proof stress in compression. The sample shall be taken from the test sample selected for tensile tests.

11.3.1 The compression test piece shall be machined out as near to the surface of the bar as possible with the axis parallel to the axis of the bar. Dimensions of the test piece shall be as given below:

Length = 20 mm ± 1.0 mm
Diameter = 20 mm ± 0.2 mm

The end faces of the test piece shall be at right angle to the axis of the test piece.

11.4 Sampling for Macro-Etching or Sulphur Print

A 15 mm slice each from the top end product of the first, middle and last ingot or cluster of ingots from each cast shall be drawn for this test. However, if agreed to by the purchaser, the middle ingot sample may be discarded.

12 RETEST

12.1 For each of the original test piece that fails to comply with the mechanical tests, two further test samples are to be selected for retests, one of which is to be from the bar or billet from which the original test sample was taken, unless that item has been withdrawn by the steel maker in which case a further bar or billet is to be selected.

12.2 Both the retest samples shall comply with the specified requirements. If any retest fails, the material representing that lot/batch shall be liable to be rejected.

12.3 For material supplied in the heat treated condition, the steel maker will have the option to reheat treat the material and resubmit it for inspection and testing.

12.4 In the case of bars for forging, if the proof stress in the original test is not more than 8 MPa below the minimum requirements, it shall be permissible for the test materials to be reduced prior to heat treatment to not less than twice the thickness at the test position of the forging that shall be made from steel.

13 CONDITION OF ACCEPTANCE

Notwithstanding the acceptance of material as complying with this specification, the material shall be liable to subsequent rejection should it fail in whole or part to meet the specification or have harmful defects, proved to have been in the steel before delivery, be revealed by forging/machining operations at the consignees end.

14 PACKING AND DESPATCH

Mode of packing and despatch shall be as agreed to between the purchaser and the supplier.

15 MARKING

The material, after tests and acceptance by the purchaser's representative, shall be marked suitably with the following details:

a) Manufacturer's name or trade-mark;
b) Heat number;
c) Heat treatment batch No. wherever applicable;
d) Purchaser's acceptance stamp; and
e) Specification number.

15.1 BIS Certification Marking

The material may also be marked with the Standard Mark.

15.1.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
228 : 1959	Methods for chemical analysis of steels
786 : 1967	Conversion factors and conversion table
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
1499 : 1977	Method for charpy impact test (U-notch) for metals (*first revision*)
1500 : 1983	Brinell hardness testing for metallic materials (*second revision*)
1598 : 1977	Method for izod impact test of metals (*first revision*)
1608 : 1995	Mechanical testing of metals — Tensile testing (*second revision*)
1757 : 1988	Method for charpy impact test (V-notch) for metallic material (*second revision*)
1852 : 1985	Rolling and cutting tolerances for hot-rolled steel products (*fourth revision*)
3703 : 1980	Code of practice for magnetic particles flaw detection (*first revision*)
3803 (Part1) : 1989	Steel — Conversion of elongation values : Part 1 Carbon and low alloy steels (*second revision*)
4163 : 1982	Method for determination of inclusion content in steel by microscopic method (*first revision*)

IS No.	*Title*
4748 : 1988	Methods for estimating average grain size of metals (*first revision*)
8910 : 1978	General technical delivery requirements for steel and steel products
11371 : 1985	Method for macro-etch test for wrought steel products
12037 : 1987	Macrographic examination by sulphur print (Baumann method)
13015 : 1991	Macro-etch testing, inspection and rating of steel products
13190 : 1991	Recommended practice for eddy current examination by rotating probe method of round steel bars

ANNEX B

(*Clause* 4.3.3)

GUIDELINES FOR INSPECTION AND TESTING

B-1 Chemical composition including residual elements namely, the Ladle Analysis Report, shall be submitted by the manufacturer or supplier. The purchaser may carry out check analysis as conformatory test. Other tests, wherever facilities are available, will be carried out at manufacturer's or supplier's premises in presence of purchaser's representative.

B-2 If the tests are required to be conducted by the purchaser at his own arrangements, the manufacturer or the supplier shall submit his pre-inspection report with the intimation for readiness of bulk. The manufacturer or supplier shall satisfy himself and certify acceptability of the material in all respects.

B-3 Surface and dimensional inspection will be carried out at supplier's premises. Adequate bonding facilities for storage of inspected material are to be provided by the manufacturer or the supplier.

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This Indian Standard has been developed from Doc : No. MTD 16 (3972).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Printograph, New Delhi, Ph : 5726847